(54) Title: QUALIFICATION SYSTEM FOR PRINTED IMAGES
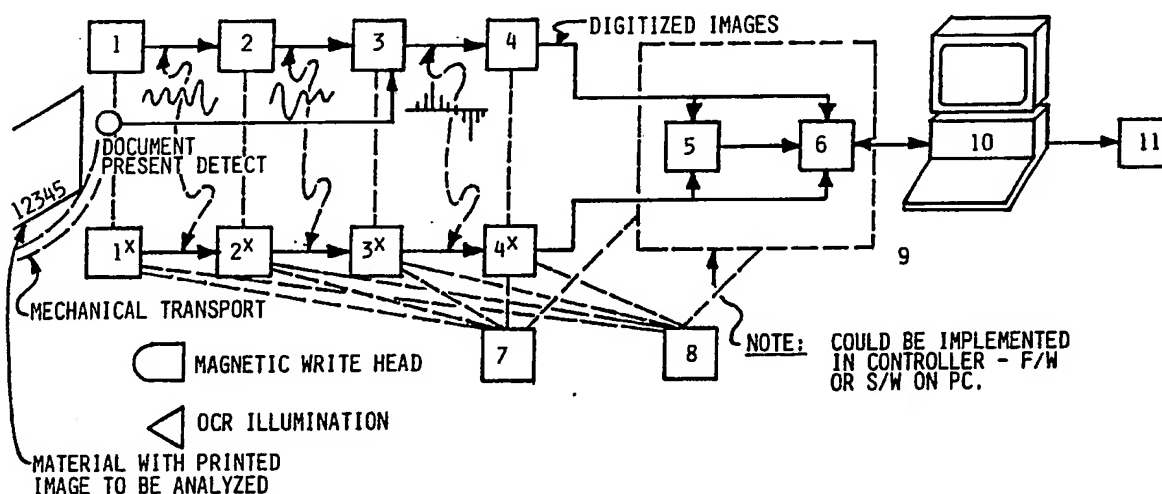
(57) Abstract

A system for automatically determining the quality of various types of printed images uses either a single element optical sensor or a multi-element sensor which may include one or more of an optical, magnetic, thermal or acoustic transducer (1, 1x). A microprocessor (9, 10) is used to store a standard set of images in its memory and automatically compares the printed images on a background material with the standard images. The microprocessor then causes the system to produce a result of said comparison. The system has various uses but is particularly useful in the banking business to process cheques.

QUALIFICATION SYSTEM FOR PRINTED IMAGES

- 1 -

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

This invention relates to a system for automatically determining the quality of various types of
5   printed images. In particular, the system electronically compares printed images to a set of standard images stored in an electronic memory.

DESCRIPTION OF THE PRIOR ART

Machines are presently available that will
10   analyze printed images on a background material for the purpose of determining how closely the input printed image conforms to a specified printed image stored in an electronic memory. However, previous machines are not satisfactory in that they are not sufficiently accurate
15   or they are not fully automatic or they require constant operator supervision or they are not sufficiently versatile or they require manual input.

SUMMARY OF THE INVENTION

It is an object of the present invention to
20   provide a system for automatically determining the quality of printed images where the system utilizes either a single element optical sensor or a multi-element magnetic and/or optical sensor or a combination thereof.

A system for automatically determining the
25   quality of printed images on a background material by comparing said images to a set of standard images stored on an electronic memory has at least one multi-element sensor that is selected from the group of magnetic or optical. The sensor is arranged to scan the printed
30   images. The sensor produces a series of analog signals in the form of a two-dimensional electronic image for said printed images. The sensor is connected to amplifiers and filters and to an analog digital converter to convert said analog signals to digital signals. There
35   are means for electronically com: ring said electronic

- 2 -

images with appropriate images of said set of standard
images. There are means for producing a result of said
comparison.

5   In a variation of the present invention, the
system has at least one sensor having an optical element
said sensor producing a series of analog signals in the
form of a two-dimensional electronic image for said
printed images.

                BRIEF DESCRIPTION OF THE DRAWINGS
10   In drawings which illustrate a preferred
embodiment of the invention:

           Figure 1A is a block diagram of one embodiment
of the invention having two transducers;

           Figure 1B is a block diagram showing a
15 breakdown of a printed image recognition logic portion of
the block diagram of Figure 1A;

           Figure 1C is a block diagram showing a
breakdown of a printed image analysis logic portion of
Figure 1A;

20   Figure 2 is a block diagram of a further
embodiment of the present invention; and

           Figure 3 is a block diagram of still a further
embodiment of the present invention.

                DESCRIPTION OF A PREFERRED EMBODIMENT
25   Referring to the drawings in greater detail, in
Figures 1A, 1B and 1C, there is shown a block diagram of
a preferred embodiment of the qualification system of the
present invention. It can be seen that the system has
one or more transducers 1, 1x. The transducers can be of
30 various types, for example, magnetic, optical, acoustic
or another type. The transducers are sensors. The
sensors are multi-element sensors in one embodiment of
the invention   : one of the elements, in all cases,
being either magnetic or optical. In another embodiment
35 of the invention, the sensor can be single element or

- 3 -

multi-element as long as the sensor always has at least
one optical element. The transducers can be single
element transducers, or a two-dimensional array of
multiple element transducers.

5   From Figure 1A, it can be seen that the
transducers 1, 1x are connected to amplifiers in filters
2, 2x respectively. The transducers produce a plurality
of analog signals for the printed images to be analyzed
and these signals are amplified and filtered to minimize
10   distortion and to remove interference from the detected
signal representing the printed images. The transducers
1, 1x are connected to analog-digital converters 3, 3x
respectively. The converters convert the analog signals
from the transducers to digital signals having a number
15   of grey levels. The digital signals are then fed into
computer interfaces 4, 4x from the converters 3, 3x
respectively. The digital signals are temporarily stored
in an electronic digital buffer memory before being input
into a special purpose firmwear logic controller and/or
20   computer 9, 10. The controller and/or computer 9, 10
perform the automatic printed image recognition function
5 and the printed image quality analysis, measurement and
readability function 6. A set of standard images is
stored in an electronic memory of the computer 10, the
25   standards being laid down by an appropriate standards
body, for example, ANSI (a trade mark), ABA (a trade
mark), ECMA (a trade mark), CBA (a trade mark) or BSI (a
trade mark). Print quality standards are also included
in the electronic memory of the computer 10. For
30   example, OCR (a trade mark), MICR (a trade mark) and BAR
CODES (a trade mark).

           The printed image recognition logic and the
printed image analysis logic in the controller 9 together
with the computer 10 electronically compare the
35   electronic images with appropriate images of the set of

- 4 -

standard images and produce a result of said comparison.
The result is communicated graphically to an operator of
the system through a peripheral 11, for example, a
printer or display, to allow the operator to interact
5 with and query the results of the printed image quality
analysis.

The system shown in Figure 1A has an optional
diagnostic logic system 7 connected thereto. The purpose
of the diagnostic logic 7 is to allow an operator to
10 determine the cause of a system fault and to correct this
fault. The fault would include any major out of
tolerance conditions detected during a system calibration
process.

As a further option, the system also contains a
15 calibration logic subsystem 8 which allows an operator to
routinely check to ensure that the system itself is
properly calibrated. The calibration of the system will
be checked by using a proprietary set of very accurate,
high quality, printed images on an appropriate background
20 carrier for example, paper, for the particular type of
useage for the system. The calibration images on the
proprietary set may be printed in the magnetic and/or
other types of inks depending on the desired use of the
system and will consist of various shapes such as bars,
25 squares, lines of various orientations and curvatures and
of varying widths, lengths, angles and spacing. When in
the calibration mode, the system will analyze the input
image of the calibration documents with respect to the
ideal prototype requirements stored in memory and use
30 this information to modify the key image quality analysis
parameters stored in the printed image recognition logic
5 and the printed image analysis logic 6.

For example, if image motion is used, the
calibration documents will allow the machine to determine
35 whether or not the transport speed is within

- 5 -

specifications and the machine will incorporate a
correction factor into the analysis if the speed is not
within specifications. As another example, if the
expected amplification factor is not within the
5 specification based on the reference levels of the
calibration documents, a correction factor will be stored
in the machine to eliminate this variation from the
actual image quality analysis. The calibration logic 8
could also be used to eliminate consistent noise. In
10 this situation, a blank document could be passed in front
of the transducer or transducers and the noise level
measured and stored. The signal could then be subtracted
from the input image signal to minimize the consistent
background noise component.
15   In Figure 1B, a block diagram is shown setting
out a further breakdown of the Printed Image Recognition
Logic (henceforth PIRL) 5 of Figure 1A. The embodiment
of Figure 1B is based on the multi-element sensor of
Figure 1A being a single slot magnetic transducer and
20 linear optical array sensor.
           In the embodiment shown in Figure 1B, the PIRL
operates on a digitized magnetic image stored in a
digital buffer memory. The image data is pre-processed
in an image filtering and thresholding processor 21 to
25 remove electrical noise and unwanted frequency
components. The optical image is also processed here to
enhance and sharpen the image and remove background
information.
           Next, the image data is scanned in a
30 segmentation module 22 to detect and locate character
data within the continuous stream of digitized data. The
appearance of a positive going peak may signal the
starting location for individual character data. The
process begins by scanning the digitized data until a
35 sample S1 is located whose value is above a primary

- 6 -

threshold T1. Several checks are then performed to test
for the presence of valid character data, namely: 1)
contiguous data values must remain above the primary
threshold level T1 for a minimum number of sample N1; 2)
5 contiguous data values must remain above a secondary
threshold level T2 for a minimum number of samples N2,
where $T2 > T1$ and $N2 < N1$; 3) the sum of the data values
for all samples whose values were continuously greater
than T1 must be greater than a minimum energy threshold
10 E1; and 4) a negative going peak of value less than T3
must be found within N3 samples of the location of S1.
When a set of samples is found which satisfies the above
criteria, a character is said to be located at S1. The
actual values selected for T1, T2, T3, N1, N2, N3 and E1
15 are dependent upon the choice of sampling density and the
resolution of the A/D converters 4, 4x.

When a character has been located at S1, key
feature extraction 23 is performed. A fixed numer N4 of
data samples immediately following S1 is scanned to
20 determine the locations and values of major peaks or
features. The value of N4 is dependent upon the font
being analyzed. The peak values of the features are
combined to produce a normalization factor which is
applied to the data for subsequent processing. Its
25 purpose is to remove the effects of magnetic signal
strength from the data so that data for all characters is
roughly the same amplitude.

The key feature data, after application of the
normalization factor, is next compared to a set of
30 standard images P(i) in module 24 stored in electronic
memory. There is one such predefined pattern for each
character in the font being analyzed. As the key feature
data for the character data being analyzed is compared to
a standard image, a "Quality of Match" figure, Q(i) is
35 generated for each pattern. The set of all Q(i) is

- 7 -

forwarded to the next and final module 25 where the final
classification decision is made.

     The image classification decision logic 25 is
presented with the set of Q(i) to make the final
5 recognition decision. The algorithm is a simple minimum
distance classifier, well described in the literature.
For the present embodiment, the Q(i) represent
"distances" of the data from the pattern. The lowest
value of Q(i) is compared to a threshold T4. If the
10 value of Q(i) is less than T4, the data is deemed to be
correspond to the standard image P(i) and the character
is recognized. If the value of Q(i) is greater than T4,
the data is deemed unrecognizable.

     The entire procedure 22 through 25 is repeated,
15 working through all data in the image buffer until the
end of data is encountered. At this point, all
characters will have been located and an attempt will
have been made to recognize them. If one or more
characters were deemed unreadable, operator intervention
20 may be required to identify the unknown characters.

     It should be noted that the PIRL function is
not an essential feature of the present invention. The
purpose of the PIRL function is to enhance the operation
of the image quality determination system by eliminating
25 the need, in most instances, for the operator to manually
input the printed image information to be analyzed.

     When all characters have been identified or
recognized, whether automatically or through operator
intervention, the image data from all sensors are passed
30 to the Printed Image Analysis Logic (henceforth PIAL)
shown in Figure 1C. Considering the present embodiment,
the digital buffer memory containing the digitized image
data acquired from each sensor 4, 4x is connected to a
series of modules 31 through 39 for print characteristics
35 measurement by control logic. The data for each sensor

- 8 -

may or may not be operated on by a particular module, depending on the nature of the print characteristic being measured. For example, for characters printed with magnetic ink, image data derived from an optical sensor

5 would not be passed to a module intended to examine the magnetic signal strength. Similarly, image data derived from a magnetic sensor would not be passed to a module intended to measure the optical print contrast ratio.

The print characteristic measurement modules 31

10 to 39 inclusive each examine a specific characteristic of the print. The characteristics that are examined are a function of the sensor(s) and the print font specification in use and may include but are not limited to the following:

15 31 Image location and spacing measurement: determining the exact placement of characters with respect to the edges of the document and with respect to each other, both horizontally and vertically;

32 Image print contrast/intensity measurement:

20 determine the absolute levels, the variation from one character to the next and the variation within a character;

33 Image skew angle measurement: determine the angle of the baseline of individual charactaers with respect to

25 the baseline of the document;

34 Image stroke width measurement: determine the widths of horizontal and vertical strokes in each character;

35 Image edge variation measurement: examine the edge regularity of horizontal and vertical strokes in each

30 character;

36 Image void measurement: examine all strokes of a character for voiding (absence of ink);

37 Image size and dimension measurement: determine the overall width and height of each character;

- 9 -

38   Image extraneous ink measurement: examine the spaces
around all strokes of each character for evidence of
unwanted ink caused by ink splattering, ribbon flaking,
etc.;

5   39   Image curvature measurement: examine individual
strokes of each character to determine the curvature of
each stroke and the radii of stroke intersections and
terminations where appropriate.

When all print characteristics have been

10   examined and measured for each character, the
measurements for an individual character are compared
with a predefined set of measurements M(i) for the
standard images, one such set existing for each
characater defined in the font being analyzed.

15   Individual measurements within each set M(i,j) are a
function of the character font and document format
requirements.

The results of the comparisons for each
character R(i) are accumulated for the document and a

20   judgment is made as to the acceptability of the print.
The criteria of the judgment are also functions of the
character font and document format requirements.

For many of the print measurements, it will be
possible and desirable to cross correlate the observed

25   measurements for each character between the data sets
derived from each sensor. For example, in the present
embodiment, vertical stroke widths can be measured both
optically and magnetically. When there is disparity
between the two measurements, special criteria will be

30   used to priorize the result, such criteria also being
based on the character font and document format
specifications. As another example, consider a print
sample consisting of a magnetic ink font which contains
non-magnetic extraneous ink splatters. The optical image

35   will show the presence of the extraneous ink while the

- 10 -

magnetic image will not. If the print specification
allows non-magnetic extraneous ink, no fault will be
issued.

5   The final result is then presented to an
operator, for example, by means of computer video
interface. The result may be condensed to a simple "Yes"
or "No" or may be accompanied with a detailed description
of print faults.

10   While Figures 1B and 1C are based on the multi-
element sensor of Figure 1A being a single slot magnetic
transducer and a linear optical array sensor, the process
of analysis is similar for other types of multi-element
sensors as well. For example, there could be two multi-
element sensors a linear magnetic array sensor and a
15 linear optical array sensor.

One type of printed character measurement
device described for this invention is based on a system
using optical sensing. Other methods of shape detection
and measurement, including magnetic, thermal and acoustic
20 are equally feasible and will be readily apparent to
those skilled in the art using the methods and devices
described.

The optical measurement device consists of
several functional blocks of equipment. These include:
25   (a) a source of illumination directed at the
               area of the document sensed by the scanner.
               The wavelength of this illumination is
               chosen so as to maximize the probability of
               reliably detecting the printed information;
30   (b) a lens capable of focussing the image of the
               area of the document to be scanned onto the
               active area of the sensor element;
        (c) a sensor controller which produces all the
               control signals required to operate the
35   sensor in an optimum synchronized manner,

- 11 -

with respect to both the measurement system
and the illumination requirements;

(d) a document transport and control system,
which moves the document into the field of
5 view of the sensor, if necessary moves it
past the sensor at a controlled rate while
the sensor scans the document and then
removes it from the field of view when
completed;

10 (e) an analog-to-digital converter which changes
the analog, time-varying signal from the
sensor into a series of equivalent numerical
values, representing the instantaneous value
of the reflected light level at appropriate
15 measurement times. The brightness
measurement resolution required by this
device will be dependent upon the type of
information to be detected. Information
which is represented as a series of very
20 gradual shares will require very fine
brightness measurement intervals.
Information which is represented as stark
black/white steps will be detectable with
very coarse brightness intervals. The
25 output of this converter is equivalent to a
digital representation of the source
document brightness;

(f) a conversion controller, which generates
control parameters for the A/D converter,
30 causing it to operate in a manner which will
ensure that all pertinent information on the
document is properly digitized and available
for subsequent analysis, with a minimum of
extraneous, unwanted background information;

35 (g) a digital image format converter, which

- 12 -

stores and reformats the image information
from the A/D converter into a form suitable
for retention in the digital image memory;

(h)   a digital image memory capable of storing
5   enough information to represent at least one
full document image. This memory receives
reflected brightness information from the
scanning device using the scanner's time
reference controller. It then produces the
10   stored information for the analysis devices
in their time scale, upon command. It is in
effect both a time compressor and expander;

(i)   a memory controller device, which operates
the image memory under control of signals
15   from both the scanning device and the image
analysis devices. This controller ensures
that information from the scanner is stored
at the appropriate place in memory at the
correct time and that the information is
20   made available to the analysis devices as it
is required by them. In addition, by
signalling the document transport
controller, it ensures that no document
information will be lost, in effect
25   controlling the flow of source documents
through the scanning device;

(j)   a device for detecting patterns of
information in the image stored in memory,
separating these patterns from the
30   background image and passing the pattern
information and pattern location information
to an information converter;

(k)   an information converter which accepts
information patterns and locations from the
35   pattern detector and converts them, if

- 13 -

necessary, to a form more suitable for use
by the recognition logic only. For example,
the shape of a character may be altered from
an exact image form to one in which the
5   character is described as a set of
predetermined features;

(1)   an information recognizer, which identifies
the converted information patterns presented
to it, using sets of pre-stored parameters
10   and recognition logic suited to the
complexity of the patterns themselves.
Patterns which cannot be recognized exactly
are marked as unknown, and the recognizer
may attempt a "best-guess" whenever the need
15   is present;

(m)   a comparator device, which compares the
recognized patterns against stored ideal
measurements, producing a quality judgment
factor which is a measurement of the
20   deviation of the original pattern detected
on the doucment from the stored ideal
pattern;

(n)   a set of decision logic which accepts the
quality factor result from the comparator,
25   and dependent upon the invention of the
measurement system, produces a measurement
result ranging from "Yes/No" to a
"percentage of acceptability";

(o)   an optional computer, which provides a means
30   of automatically operating the measurement
system unattended, storing measurement
results for statistical purposes and.
presenting these results to an operator in a
meaningful form.

- 14 -

In Figures 2 and 3, there are shown two
embodiments respectively of optical printed shape
measurement devices. These embodiments are self-
explanatory in view of the description already set out
5 for the block components.

The present invention is a general purpose
print quality analysis/measurement system which actually
senses or detects the printed image through sensors
having one or more transducers. The background material
10 on which the image is printed can be either transported
by the transducer or the transducer itself can be moved
over the image to be sensed. Various types of background
material for the printed images are suitable, for
example, paper, plastic and textiles. Various types of
15 print can be analyzed, for example, bar codes, logos and
alpha numeric using a variety of printing inks, for
example, magnetic, optical, flourescent and embossed.
The image can also be sensed using a transducer which can
scan the complete image with no mechanical movement of
20 the image or transducer.

As previously stated, the transducer(s) can be
of various types, including optical, magnetic and/or
acoustic. A transducer may be used in the system alone
if the transducer is an optical transducer or in
25 combination with other transducers. The type of
transducer to be used depends on the physical image
attributes to be detected and analyzed. For example, the
acoustic transducer may be used to sense and measure the
raised print on an embossed plastic credit card. An
30 optical transducer may be used to detect the print of the
OCR and magnetic fonts. A magnetic transducer may be
used to detect the magnetic image information in
magnetically printed fonts such as E13B (a trade mark)
and CMC-7 (a trade mark). A combination of optical and
35 magnetic transducers for example could be used to detect

- 15 -

the optical and magnetic print image and characteristics
for automatic analysis by the print quality analysis and
measurement system.

  Single element transducers require that the
5 printed image to be sensed and transducer be moved with
respect to each other such that the whole image is
scanned by the transducer. The transducer thus outputs
an analog waveform which represents the original image.
This analog waveform is typically amplified and filterd
10 and have conditioned by these various and other signal
processing means to minimize distortion and remove
interference from the detected signal representing the
image. After conversion from analog waveform to digital
the waveform is then sent to the PIRL and/or PIAL
15 (Printed Image Analysis Logic) to analyze the specific
quality characteristics of the waveform with respect to
the ideal specified waveform stored for that particular
image. The waveform thus represents a transformed
version of the original image with some information loss
20 but which is a lower cost version of the multiple element
transducer approach.

  A linear or one-dimensional multiple element
transducer produces a number of analog signals
representing various points on the image when the
25 transducer and image are moved with respect to each
other. This process in effect produces a two-dimensional
electronic "image" of the original printed image. The
electronic "image" thus produced will have a certain
spatial resolution depending upon the sampling density of
30 the transducer. The multiple transducer element analog
signal samples are then amplified via multiple amplifiers
and the signals are conditioned by various multiples of
filters and minimum signal level thresholders before
being converted to digital signals by the A/D converters.
35 The digital image representation is then analyzed and

- 16 -

measured and compared to the image specification
requirements stored in memory. The output from this
process gives a measure of the quality and automated
machine readability of the original printed image.

5   Two-dimensional array transducers also produce
a two-dimensional electronic image of the original
printed image except that once the image to be scanned is
placed in front of the two-dimensional transducer array
and the scanning action is initiated, either manually or
10   automatically, no motion of the image to be scanned or
the transducer is required since the two-dimensional
transducer scans electronically.

This invention is primarily aimed at the
analysis and measurement of a variety of types of printed
15   images sensed by multiple element transducers to
determine their quality and machine readability to a
specific standard. The inputs from single element
transducers are an aid to the multiple element
transducers in this process. However, where the
20   transducers are optical transducers, they can be single
or multiple element transducers and they can be used
along or together with other transducers, within the
scope of the attached claims.

One of the more common implementations of the
25   invention will involve a combination of at least two
different types of transducers. The two most likely
combinations are; 1) a single element magnetic transducer
and a multiple element one-dimensional linear array
optical transducer, or 2) a multiple element magnetic
30   transducer and a multiple element one-dimensional optical
linear array.

The most common single transducer
implementations of the invention will be 1) multiple
element magnetic 2) multiple element one-dimensional
35   optical 3) multiple element two-dimensional optical 4)

- 17 -

single element magnetic, when accompanied by another
multiple element transducer 5) single element optical.

The image qualification system of the present
invention can be implemented using a combination of
5   hardware, firmware and software. Essentially, referring
to Figure 1A, all the functions 1 to 4, inclusive, could
be implemented in hardware and the functions 5 to 8,
inclusive, could be implemented in firmware in a
programmable logic controller or in software in a
10 personal computer. In the case where the quality
analysis logic is implemented in software, the program
algorithms and logic will be protected by copyright.

The system of the present invention has the
ability to collect, accumulate, analyze and communicate
15 the printed image quality statistics over a range of
sample and/or time set by the system operator. A
specific software module will perform this function in
the personal computer.

Some specific applications of the present
20 invention will be in the area of alpha-numeric and
special symbols as used in the item processing industry.
The qualification system of the present invention
provides improved results whether multi-element sensors
are used or a single element optical sensor is used.

- 18 -

The embodiments of the invention in which an exclusive
property or privilege is claimed are defined as follows:

1.   A system for automatically determining the
quality of printed images on a background material by
5   comparing said images to a set of standard images stored
in an electronic memory, said system comprising:

(a)   at least one multi-element sensor
        that is selected from the group of
        magnetic or optical, said sensor being
10   arranged to scan the printed images, said
        sensor producing a series of analog signals
        in the form of a two-dimensional electronic
        image for said printed images;
(b)   said sensor being connected to amplifiers
15   and filters and to an analog-digital
        converter to convert said analog signals to
        digital signals;
(c)   means for electronically comparing said
        electronic images with appropriate images of
20   said set of standard images; and
(d)   means for producing a result of said
        comparison.

2.   A system as claimed in Claim 1 wherein the
system has at least two multi-element sensors one sensor
25   being a single element magnetic transducer and another
sensor being a linear optical array sensor.

3.   A system as claimed in Claim 1 wherein the
system has at least two multi-element sensors one sensor
being a linear magnetic array sensor and another sensor
30   being a linear optical array sensor.

4.   A system as claimed in Claim 1 wherein the
system has at least two sensors one sensor being a single
element magnetic transducer and the other sensor being a
two-dimensional optical array.

- 19 -

5.   A system as claimed in Claim 1 wherein the at
least one multi-element sensor is a multiple element
magnetic transducer.

6.   A system as claimed in Claim 1 wherein the at
5   least one multi-element sensor is a multiple element two-
dimensional optical transducer.

7.   A system as claimed in Claim 1 wherein the at
least one multi-element sensor is a multiple element one-
dimensional optical transducer.

10   8.   A system as claimed in Claim 1 wherein the
system has at least two multiple element sensors, one
sensor being a two-dimensional optical sensor and another
sensor being a multiple element magnetic transducer.

9.   A system as claimed in Claim 1 wherein the
15   means for electronically comparing said electronic images
with appropriate images of said set of standard images
and the means for producing a result of said comparison
is a microprocessor controlled by software, firmware or
logic.

20   10.   A system as claimed in Claim 9 wherein there is
a printer connected to the microprocessor to print out
the results of the comparison.

11.   A system as claimed in Claim 1 wherein there is
a monitor connected to the microprocessor to display the
25   results.

12.   A system as claimed in Claim 1 wherein there is
a sensor controller for the multi-element sensor.

13.   A system as claimed in Claim 12 wherein the
sensor has an optical transducer and there is a source of
30   illumination and a lens for said optical transducer.

14.   A system as claimed in Claim 1 wherein there
are means to transport the printed images relative to the
sensor or sensors in order to scan said images.

15.   A system as claimed in Claim 1 wherein the
35   sensor or sensors have a multi-slot transducer that scans

- 20 -

the printed images without relative movement of the
images past the transducer.

16.   A system as claimed in Claim 1 wherein there
are means for automatically calibrating the system.

17.   A system as claimed in Claim 1 wherein the
system contains a diagnostic subsystem to provide an
automatic check on the system.

18.   A system as claimed in Claim 1 wherein the
means for electronically comparing the electronic images
with appropriate images of said set of standard images is
a two-step process involving firstly a determination
based on whether the printed images can be recognized and
secondly an analysis of said printed images.

19.   A system as claimed in Claim 18 wherein the
means for electronically comparing said images is a
microprocessor.

20.   A system as claimed in Claim 19 wherein the
microprocessor can produce results for a series of
samples simultaneously.

21.   A system for automatically determining the
quality of printed images on a background material by
comparing said images to a set of standard images stored
in an electronic memory, said system comprising a at
least one sensor having an optical element, said sensor
being arranged to scan the printed images, said sensor
producing a series of analog signals in the form of a
two-dimensional electronic image for said images, said
sensor being connected to amplifiers and filters and to
an analog-digital converter to convert said analog
signals to digital signals, means for electronically
comparing said electronic images with appropriate images
of said standard images and means for producing results
of said comparison.

- 21 -

22.   A system as claimed in Claim 21 wherein the
sensor has an optical transducer and there is a source of
illumination and a lens for said optical transducer.

23.   A system as claimed in Claim 22 wherein the
5 sensor is a multi-element sensor and produces a series of
analog signals in the form of a two-dimensional
electronic image for said printed images.

AMENDED CLAIMS
[received by the International Bureau on 12 June 1989 (12.06.89)
original claims 1,8,9,16,17,18,19,21 amended; new claims 24 added;
other claims unchanged (4 pages)]

The embodiments of the invention in which an exclusive
property or privilege is claimed are defined as follows:

1.   A system for automatically determining the
quality of printed images on a background material by
5   analyzing said images by comparing them to a set of print
characteristics for standard images stored in an
electronic memory, said system comprising:
        (a) at least one multi-element sensor
             that is selected from the group of
10   magnetic or optical, said sensor being
             arranged to scan the printed images, said
             sensor producing a series of analog signals
             in the form of a two-dimensional electronic
             image for said printed images;
15   (b) said sensor being connected to amplifiers
             and filters and to an analog-digital
             converter to convert said analog signals to
             digital signals;
        (c) means for electronically analyzing said
20   electronic images by measuring and otherwise
   comparing them to print characteristics of
             appropriate images of said set of standard
             images; and
        (d) means for producing a result of said
25   comparison.
    2.   A system as claimed in Claim 1 wherein the
system has at least two multi-element sensors one sensor
being a single element magnetic transducer and another
sensor being a linear optical array sensor.
30 3.   A system as claimed in Claim 1 wherein the
system has at least two multi-element sensors one sensor
being a linear magnetic array sensor and another sensor
being a linear optical array sensor.
    4.   A system as claimed in Claim 1 wherein the
35 system has at least two sensors one sensor being a single

element magnetic transducer and the other sensor being a
two-dimensional optical array.

5.   A system as claimed in Claim 1 wherein the at
least one multi-element sensor is a multiple element
5   magnetic transducer.

6.   A system as claimed in Claim 1 wherein the at
least one multi-element sensor is a multiple element two-
dimensional optical transducer.

7.   A system as claimed in Claim 1 wherein the at
10   least one multi-element sensor is a multiple element one-
dimensional optical transducer.

8.   A system as claimed in Claim 1 wherein the
system has at least two multiple element sensors, one
sensor being a two-dimensional optical sensor and another
15   sensor being a multiple element magnetic transducer.

9.   A system as claimed in Claim 1 wherein the
means for electronically analyzing said electronic images
by measuring and otherwise comparing them to print
characteristics of appropriate images of said set of
20   standard images and the means for producing a result of
said comparison is a microprocessor controlled by
software, firmware or logic.

10.   A system as claimed in Claim 9 wherein there is
a printer connected to the microprocessor to print out
25   the results of the comparison.

11.   A system as claimed in Claim 1 wherein there is
a monitor connected to the microprocessor to display the
results.

12.   A system as claimed in Claim 1 wherein there is
30   a sensor controller for the multi-element sensor.

13.   A system as claimed in Claim 12 wherein the
sensor has an optical transducer and there is a source of
illumination and a lens for said optical transducer.

24

14.   A system as claimed in Claim 1 wherein there
are means to transport the printed images relative to the
sensor or sensors in order to scan said images.

15.   A system as claimed in Claim 1 wherein the
5 sensor or sensors have a multi-slot transducer that scans
the printed images without relative movement of the
images past the transducer.

16.   A system as claimed in Claim 1 wherein there
are means for automatically calibrating the system.

10 17.   A system as claimed in Claim 1 wherein the
system contains a diagnostic subsystem to provide an
automatic check on the system.

18.   A system as claimed in Claim 1 wherein the
means for electronically analyzing the electronic images
15 by measuring and otherwise comparing them to print
characteristics of appropriate images of said set of
standard images is a two-step process involving firstly a
determination based on whether the printed images can be
recognized and secondly an analysis of said printed
20 images.

19.   A system as claimed in Claim 18 wherein the
means for electronically analyzing said images is a
microprocessor.

20.   A system as claimed in Claim 19 wherein the
25 microprocessor can produce results for a series of
samples simultaneously.

21.   A system for automatically determining the
quality of printed images on a background material by
analyzing said images by comparing them to a set of print
30 characteristics for standard images stored in an
electronic memory, said system comprising at least one
sensor having an optical element, said sensor being
arranged to scan the printed images, said sensor
producing a series of analog signals in the form of a
35 two-dimensional electronic image for said images, said

sensor being connected to amplifiers and filters and to
an analog-digital converter to convert said analog
signals to digital signals, means for electronically
analyzing said electronic images by measuring and
5 otherwise comparing them to print characteristics of
appropriate images of said set of standard images and
means for producing results of said comparison.

22.   A system as claimed in Claim 21 wherein the
sensor has an optical transducer and there is a source of
10 illumination and a lens for said optical transducer.

23.   A system as claimed in Claim 22 wherein the
sensor is a multi-element sensor and produces a series of
analog signals in the form of a two-dimensional
electronic image for said printed images.

15 24.   A system as claimed in any one of Claims 19, 21
or 22 wherein the print characteristics that are analyzed
are selected from the group of image location and spacing
measurement; image print contrast/intensity measurement;
image skew angle measurement; image stroke width
20 measurement; image edge variation measurement; image void
measurement; image size and dimension measurement; image
extraneous ink measurement; and image curvature
measurement.

FIGURE 1A
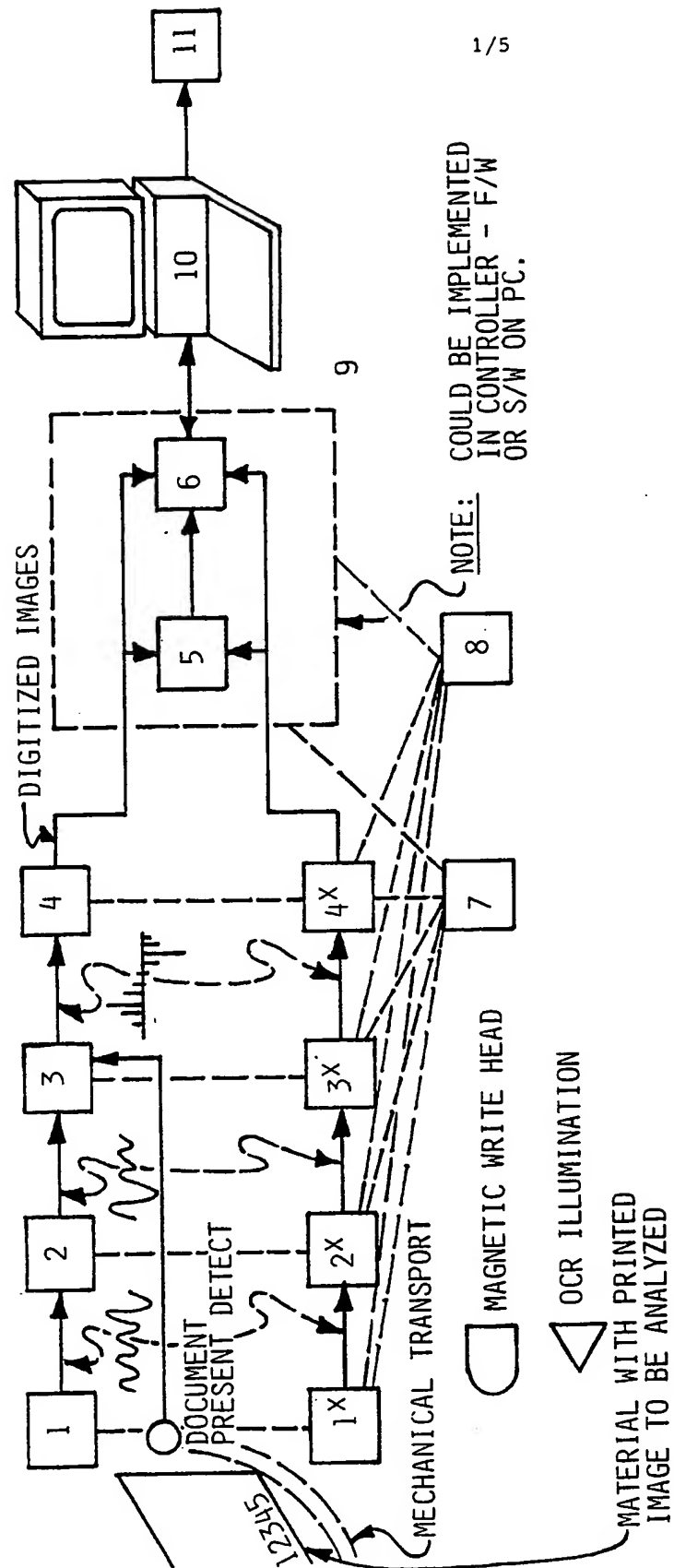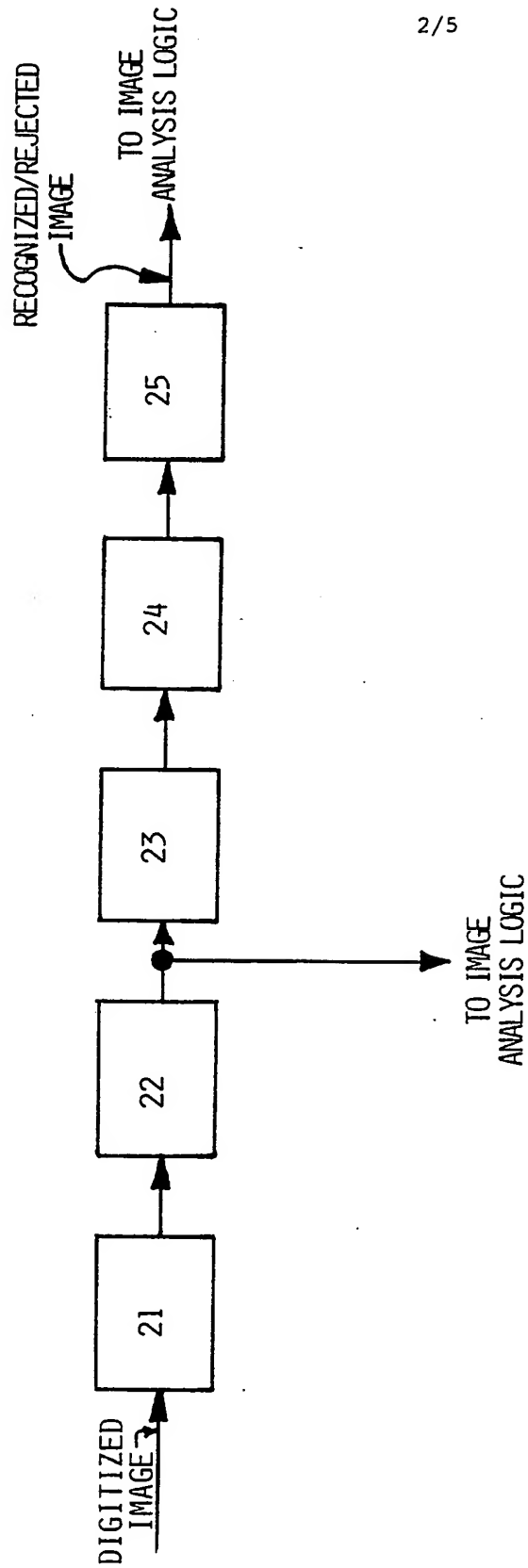
FIGURE 1 B

FIGURE 1 C

FIGURE 2

5/5
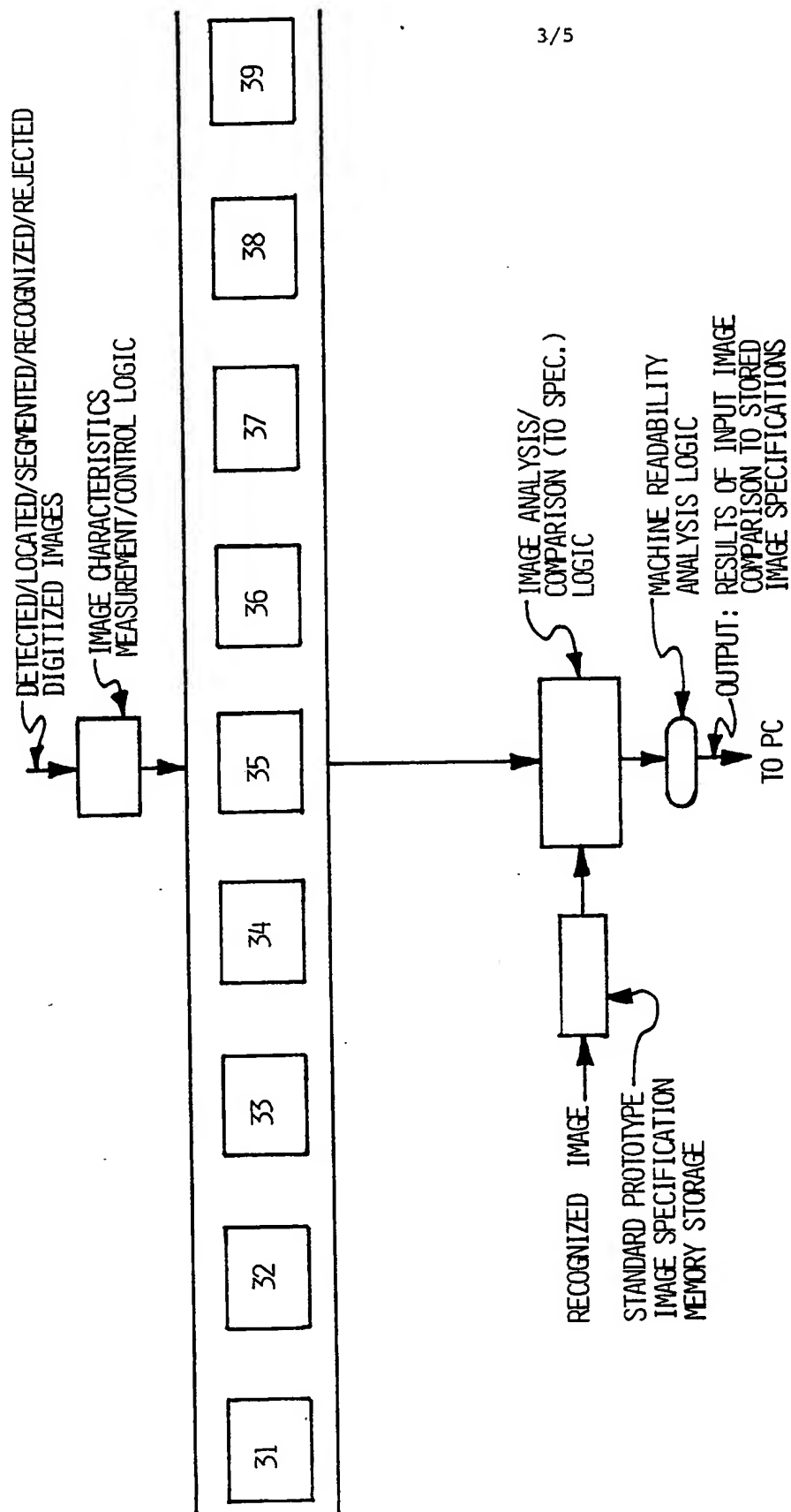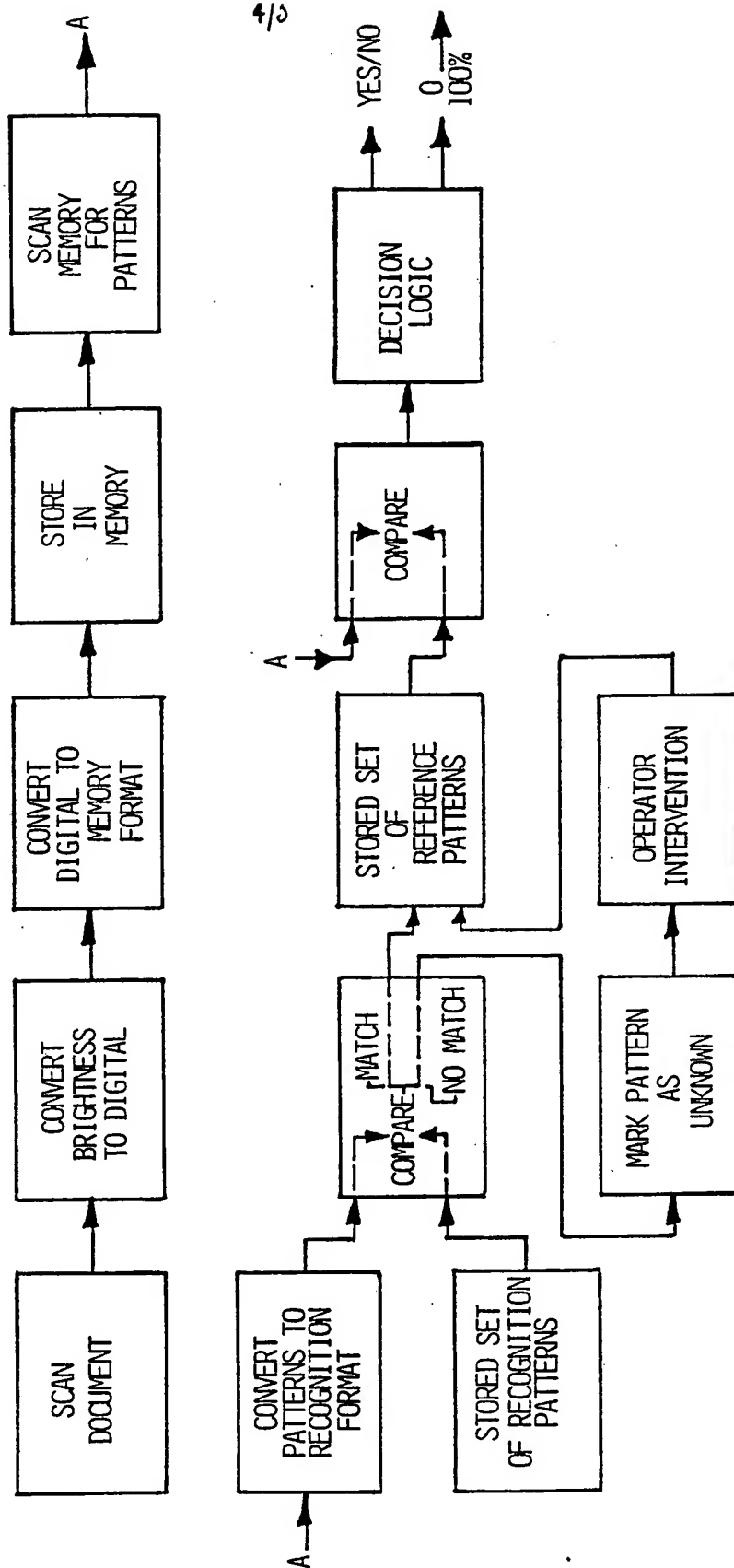
FIGURE 3
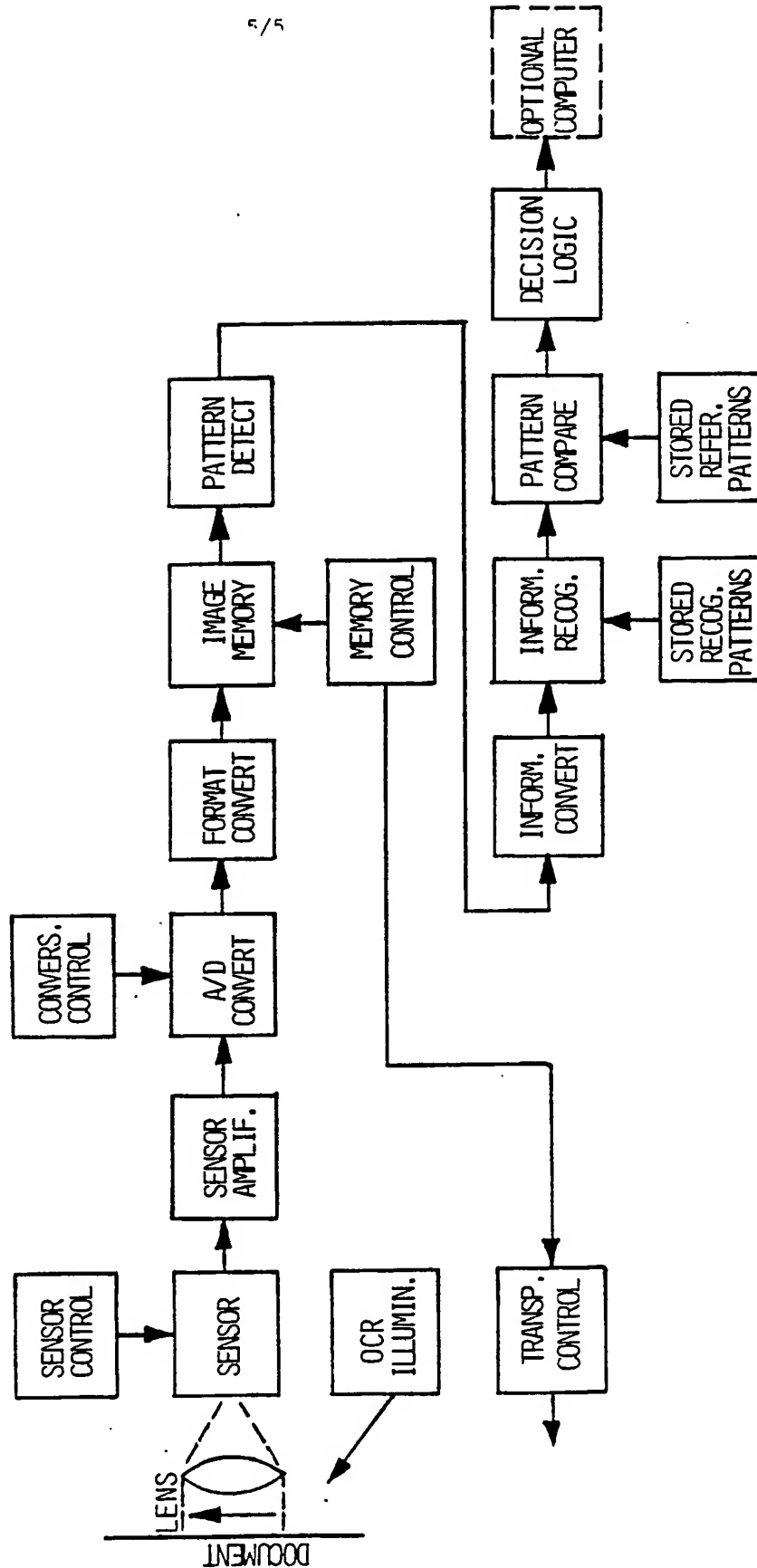
INTERNATIONAL SEARCH REPORT

International Application No. PCT/US89/00515

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. CL.[4]   G06K 9/00
U.S. CL.   382/7, 34, 64

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S.	235/449 358/282 382/7, 34, 58, 64, 65, 67

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US, A 4,205,780 Burns et al. 3 June 1980 (3.6.80) see Figs. 1 and 5 and column 8, line 55 to column 9, line 32.	1, 2, 4, 6, 7, 9, 11-15 and 18-23
X	US, A, 4,555,617 Brooks et al. 26 November 1985 (26.11.85) Figs. 1A, 1B and 3 and column 6, lines 24-54 and column 7, line 21 through column 8, line 17.	1, 2, 4, 6, 7, 9 and 11-23
X	US, A, 4,523,330 Cain 11 June 1985 (11.6.85) see Figs. 1, 2A, 2B, 3, 4 and 6 and column 4, line 46 through column 5, line 61.	1, 2, 4, 6, 7 and 9-23
X	US, A,4,685,141 Hoque et al. 4 August 1987 (4.8.87) see Figs. 1, 2A, 2B, 4, 5, 7A and 7B and column 3, line 29 through column 10, line 63.	1, 2, 4, 6, 7 and 9-23
X	US, A,3,863,219 Rohrer 28 January 1975 (28.1.75) see Fig. 4 and column 4, line 61 through column 5, line 19.	1 and 5
Y	US, A,3,863,219 Rohrer 28 January 1975 (28.1.75) see Fig. 4 and column 5, lines 1-2.	3 and 8
Y	US, A,4,356,473 Freudenthal 26 October 1982 (26.10.82) see Fig. 3 and column 2, lines 50-54. (continued)	3 and 8

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search

March 14, 1989

Date of Mailing of this International Search Report

12 APR 1989

International Searching Authority

ISA/US

Signature of Authorized Officer

Jose L. Couso

Form PCT/ISA/210 (second sheet) (Rev.11-87)

III. DOCUMENTS CONSIDERED TO BE RELEVANT   (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	US, A 4,490,850 Nally et al. 25 December 1984 (25.12. 84) see Fig. 1 and column 3, lines 44-48.	3 and 8
A	US, A. 4,315,246 Milford 9 February 1982 (9.2.82) see Fig. 1.	1-23
A	US, A,3,764,978 Tyburski 9 October 1973 (9.10.73) see Fig. 1.	1-23
A	US, A,3,949,363 Holm 6 April 1976 (6.4.76) see Figs. 1 and 4.	1-23

Form PCT/ISA/210 (extra sheet) (Rev.11-87)